In the course of his work Prof. Dittmar hit upon an elegant method of determining densities, which was found to be very satisfactory. He filled a water-bath with a particular sea-water that had been selected as a standard, and kept it at a constant temperature. A specific-gravity bottle was filled with the same water, stoppered, hung in the bath to the balance-pan, and weighed accurately. To compare any number of samples of water it was sufficient to fill up the bottle with the water in question, and again weigh it immersed in the standard. Prof. Dittmar confined himself to making out the relation between salinity, specific gravity, and temperature, leaving the relation of specific gravity and pressure for subsequent treatment by Prof. Tait, whose great chain of experiments on the compressibility of sea-water is now drawing to a close, and the results of which will shortly be published in the *Challenger* Reports. The conclusion Prof. Dittmar comes to is summed up in the formula—

$$\chi = \frac{{}_4S_t - {}_4W_t}{a + bt + ct^2},$$

where χ is the "salinity" or permilleage of halogen; ${}_4S_t$ the specific gravity of sea-water at t° relatively to pure water at 4° C.; ${}_4W_t$ is the specific gravity of pure water in the same way; a, b, and c are constants which have been determined once for all.

In the chapter on Salinity in Part I. Prof. Dittmar gives a table dealing with 300 samples, collected in all parts of the ocean and from all depths. These tables show the position, the depth of the ocean at the station, the depth from which the sample was drawn, the permilleage of chlorine (χ), the mean deviation of the mean χ from the individual results, and the difference between the amount of chlorine as calculated from Buchanan's observations of specific gravity, and as found directly by Dittmar.

Mr. Buchanan gives in his report all his observations classified according to geographical position and depth, and arranged in eighteen large tables. These record the specific gravity of water from all depths in the North and South Atlantic, the Southern Indian Ocean, the North and South Pacific, and the interesting inclosed seas of the Malayan Archipelago. The numbers are simply given as they were observed, only corrected for temperature by Dittmar's table, and all discussion of their oceanographic significance has been deferred until a subsequent occasion.

A series of coloured charts illustrating the bathymetrical and geographical distribution of specific gravity over the whole world and in the individual oceans accompanies the memoir. These are extremely interesting, and in many cases they tell their own story without explanation, though when the full descriptions are published, the value and interest of the plates will be greatly increased. The track-chart of the *Challenger* coloured to show the surface salinity of the ocean, is especially worthy of notice; its details have been filled in, and the whole rendered more complete, by the incorporation of the results of other exploring expeditions.

The great importance of Mr. Buchanan's specific gravity observations will be more readily recognised by the general reader when they are elucidated by the work of Prof. Tait and Mr. Buchan, and treated more generally than is possible in a mere statement of observed figures.

The third part of the volume is devoted to the temperature observations made during the cruise. The nature of the information contained in the curves which make up this part of the work is very concisely put in the editor's introduction:—

"It has been deemed advisable to publish, for the convenience of scientific men, the whole of the deep-sea observations of temperature made during the voyage of the *Challenger*. These are given in detail in the accompanying series of 263 plates, which show the latitude and longitude of the station; the depth in fathoms of the bottom; the depth at which each temperature was taken; the number of the thermometer; the temperature actually observed read to quarter degrees; the error of the thermometer; and the temperature corrected for instrumental error only."

The temperatures have been plotted by Staff-Commander Tizard, and a free-hand curve drawn through the points. From this the "temperature by curve" which is employed in drawing the diagrammatic sections of the ocean showing the bathymetrical arrangement of the isothermals is taken. These sections will be published in vol. i. of the *Challenger* narrative, and to the general reader they will present a much more intelligible idea of the distribution of oceanic temperature than can be given by the study of tables of figures or curves for separate stations. The separate station curves are, however, of the utmost value to any one who wishes to make a detailed study of ocean temperatures. With a direct view to such a purpose the curves have been drawn with rigid adherence to the numbers in the observation books, even the most obvious cases of observational error being left uncorrected; for the specialist can easily discover and correct them himself, and no one else will notice them.

The temperature observations, like the specific gravity observations, form a rich mine of material with which good work may be done. It is shown by a glance at the charts that there are areas in the ocean of great salinity and areas of great dilution; it is shown that the pressure increases uniformly with the depth; it is known that the surface temperature of the water varies greatly in different latitudes, and that, as the depth increases, the temperature decreases, at first very rapidly, but after the first few hundred fathoms with increasing slowness, until at the bottom the temperature of the open ocean is everywhere the same, between 34° and 35° F.; it is known also that in inclosed seas, or in those where there are submarine barriers cutting them off from the rest of the ocean, the temperature assumes a constant value in its descent, and sometimes the bottom is nearly 20° F. warmer than that of the ocean at the same depth a few miles distant; but this is all that is known. It is evident that there must be an ocean circulation on a magnificent scale going on, a gradual onward sweep of the whole mass of the water, but the direction of this mass motion can only as yet be guessed at, and its rate is utterly unknown. The material for solving this, the great oceanographic problem, is rapidly accumulating, and when the physical and chemical reports of the *Challenger* Expedition have all been made public, it will be strange indeed if a large generalisation cannot be based upon them, and the discovery of the secret of ocean circulation be added to the many discoveries which have been made by the scientific men of the cruise.

The nature of this volume, both on account of the subjects with which it deals and the number of formulæ and long tables of numbers it contains, must have made the task of editing it no light one; and the accuracy of every part, the almost entire absence of typographical errors, and the beauty of the lithographed charts show that authors, editor, engravers, and printers have alike exerted themselves to produce a volume worthy of being the first to record the physical and chemical work of the *Challenger* Expedition. HUGH ROBERT MILL

SPECIALISATION IN SCIENTIFIC STUDY[1]

THERE once was a science called "natural philosophy," which, like some old synthetic types of animals, held in itself all the learning that applied to physical facts. By the beginning of this century this science of natural things had become divided into physics and natural history. These divisions have since spread,

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[1] From *Science*.

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like the divisions of a polyp community, until now natural history has more than a dozen named branches; and in physics the divisions are almost as numerous. There are now at least thirty named and bounded sciences; each name designating a particularly limited field, in which there are able men who work their days out in labour that does not consider the rest of nature as having any relation to their work.

This progressive division of labour follows a natural law: and it is perhaps fit that science should itself give a capital illustration of the application of this law to forms of thought, as well as to the more concrete things of the world; but it is an open question whether or no it is advantageous to the best interests of learning. There can be no question that the search for truth of a certain quality is very greatly helped by this principle of divided labour. If a man wish to get the most measurable yield out of the earth in any way, the best thing for him is to stake off a very small claim, tie himself down to it, fertilise it highly, till it incessantly, and forget that there are blossoms or fruit beyond his particular patch; for any moment of consciousness of such impracticable things as grow beyond his field is sure to find expression when he comes to dig his crop, whether his crop in the intellectual field be elements or animals, stars or animalculæ. The harvest of things unknown is most easily won in this kitchen-gardening way of work.

The world needs, or fancies that it needs, this kind of work; and it is now of a mind to pay more of its various rewards for the least bit of special and peculiar knowledge than for the widest command of varied learning. In a thousand ways it says to its students, not only as of old, "Study what you most affect," but, "*Effect that study altogether*, know the least thing that can be known as no one else knows it, and leave the universe to look after itself."

This is the prescription of our time. We are now proceeding on the unexpressed theory that, because no man can command the details of all science, therefore he shall know only that which he can know in the utmost detail. We seem to be assuming, that, if many separate men each know some bit of the knowable, man in general will in a way know it all; that when, in another hundred years of this specialisation, we have science divided into a thousand little hermit-cells, each tenanted by an intellectual recluse, we shall have completed our system of scientific culture. No one can be so blind to the true purposes of learning as to accept this condition of things as the ideal of scientific labour. It may be the order of conquest, the shape in which the battle against the unknown has to be fought; but beyond it must lie some broader disposition of scientific life,—some order in which the treasures of science, won by grim struggle in the wilderness of things unknown, may yield their profit to man.

The questions may fairly be asked, whether we have not already won enough knowledge from nature for us to return, in part, to the older and broader ideal of learning; whether we may not profitably turn away a part of the talent and genius which go to the work of discovery to the wider task of comprehension; whether we may not again set the life of a Humboldt along with the life of a Pasteur, as equally fit goals for the student of nature.

Until we set about the system of general culture in science, it will be nearly impossible to have any proper use of its resources in education. A sound theory of general culture in science must be preceded by a careful discussion of the mind-widening power of its several lines of thought. This determination cannot be made by men versed only in their own specialties; it must be made by many efforts to determine by comparison what part of the sciences have the most important power of mind-developing. At present there are few men whose opinion on such a subject is worth anything, and the number constantly grows less.

The greatest difficulty partly expresses itself in, and partly rises from, the multiplication of societies which include specialists as members, and specialties as the subjects of their discussions. We no longer have much life in the old academies, where men of diverse learning once sought to give and receive the most varied teaching. The geologists herd apart from the zoologists: and in zoology the entomologists have a kingdom to themselves; so have the ornithologists, the ichthyologists, and other students. "That is not my department," is an excuse for almost entire ignorance of any but one narrow field. If naturalists would recognise this "pigeon-holing," not only of their work, but of their interests, as an evil, we might hope to see a betterment. Until they come to see how much is denied them in this shutting-out of the broad view of nature, there is no hope of any change. Special societies will multiply; men of this sort of learning will understand their problems less and less well; until all science will be "*caviare* to the general," even when the general includes nearly all others beyond the dozen experts in the particular line of research.

The best remedy for this narrowing of the scientific motive would be for each man of science deliberately to devote himself, not to one, but to two ideals, *i.e.* thorough individual work in some one field, and sound comprehension of the work of his fellows in the wide domain of learning—not all learning, of course, for life and labour have limits, but of selected fields. In such a system there will be one society-life meant for the promotion of special research, and another meant for the broader and equally commendable work of general comprehension.

It is in a certain way unfortunate that investigation is to a great extent passing out of the hands of teachers. This, too, is a part of the subdivision work; but it is in its general effects the most unhappy part of it. As long as the investigator is a teacher, he is sure to be kept on a wider field than when he becomes a solitary special worker in one department.

The efforts now being made for the endowment of research will, if successful, lead to a still further tendency to limit the fields of scientific labour. A better project would be to keep that connection between inquiry and exposition from which science has had so much profit in bygone times.

TWO GREEK GEOMETERS

DR. ALLMAN in his article "On Greek Geometry from Thales to Euclid," in the current volume of *Hermathena* (vol. v. No. 10), discusses in Chapter IV. the discoveries of Archytas of Tarentum, and in Chapter V. those of the Greek geometer Eudoxus of Cnidus.

Archytas was a contemporary of Plato (428–347 B.C.), probably senior to him, and saved his life when Plato was in danger of being put to death by the younger Dionysius. These particulars and others of interest are skilfully arrayed by the author; one only of these we recall, viz. Horace's reference to the death of Archytas by shipwreck in an ode (Book I. 28), in which he recognises his eminence as an arithmetician, geometer, and astronomer. Unfortunately no undoubted works of his have come down to us; the authenticity of some that have been attributed to him is here discussed, but these do not treat of geometry. In former chapters his contributions to the doctrine of proportion and his demonstrations of theorems as well as solutions of problems have been noticed. Here the question of his identity with the Architas of Boethius' *Ars Geometricæ* is discussed, and a strong case made out for the same. The connection of Archytas with the Delian Problem (already touched upon in *Hermathena*, vol. iv.) next comes under consideration, and the passage in Eutocius is translated at length and accompanied by a figure. An enumeration of the theorems which occur in this passage is made,

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